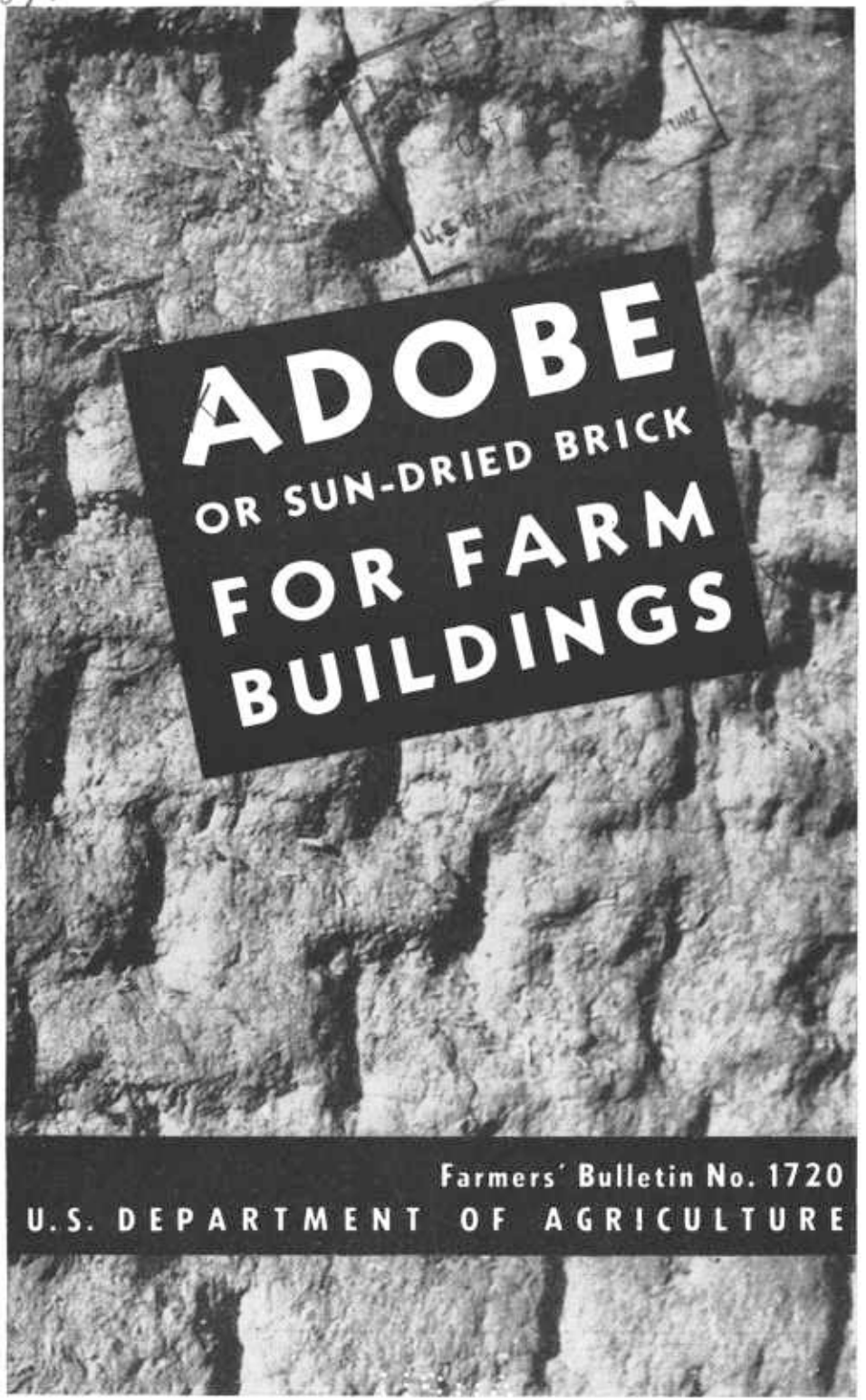

ADOBE
OR SUN-DRIED BRICK
FOR FARM BUILDINGS

Farmers' Bulletin No. 1720
U.S. DEPARTMENT OF AGRICULTURE

IN MANY localities the cost of farm buildings may be lowered considerably by using materials obtainable on or near the farm, such as logs, stone, sand, gravel, or earth. These materials, being easily accessible, do not involve heavy transportation charges and, when used in buildings of simple form, do not require the employment of skilled labor.

This bulletin describes the method of making and using adobe in the form of sun-dried bricks. The material consists of a mixture of clayey loam, straw, and water. It is of proven value as a material for walls, its use being traditional in the arid and semiarid areas of the Southwest.

The so-called adobe soils are not essential to this type of construction, since most clayey loams are suitable. Nor is adobe construction limited to arid regions; it can be employed in fairly humid climates, provided the walls are protected from moisture and the building site is not subject to floods or excessive dampness.

Very comfortable adobe houses have been built with only a small cash outlay and with unskilled labor. Many farmers might well consider the use of this material, at least in certain minor structures.

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ADOBE OR SUN-DRIED BRICK FOR FARM BUILDINGS

By T. A. H. MILLER, formerly *agricultural engineer, Division of Plans and Service, Bureau of Plant Industry, Soils, and Agricultural Engineering*[1]

Contents

ADOBE, as a building material, has been employed in the southwestern part of the United States since the time of the early Spanish settlers. It consists of a mixture of clayey loam, straw or

Figure 1.—Sun-dried brick used in building walls. The chimney and fireplace are of the same material.

other suitable bonding material, and water. When dried it becomes hard and durable.

In the United States the use of sun-dried brick (fig. 1), which is described and recommended in this bulletin, has almost entirely replaced the older custom of piling the mud in layers on the wall.

[1] Revised by E. G. Molander, senior agricultural engineer, Division of Farm Buildings and Rural Housing, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration.

The small cash outlay required for materials and the fact that skilled labor is not necessary permit the construction at a low cost of buildings (fig. 2) that are durable, fire-resistant, and comfortable.

Figure 2.—This 34- by 36-foot unheated house includes oak floors and a 14- by 18-foot garage. It was built in 1931 for $3,000.

The effective insulation afforded by earth protects interiors from the cold of winter and the heat of summer and makes adobe walls very desirable for many kinds of farm storage. Earth walls are not so subject to sweating as are those of unfurred masonry.

Figure 3.—The shaded areas are those in which adobe has been used in building construction.

RELATION TO CLIMATIC CONDITIONS

Builders in the Southwest do not hesitate to use adobe, and in many sections it is preferred to other materials. The extensive use of this material in the arid Southwest is perhaps due to the climate, which is favorable for drying the brick economically out of doors, and to the fact that it has been used for so many years that workmen have become adept in handling it.

The areas in which adobe construction is practiced are indicated in figure 3. Its use is not restricted to arid areas; it has been utilized also in humid regions having a climate favorable for curing the blocks. In such climates the walls must be well protected against moisture and the building site must not be subject to floodwaters or excessive dampness. The barracks and other buildings at Fort Niobrara, in northern Nebraska, were of adobe brick and stood for many years. An adobe building stuccoed with lime mortar stood for more than 150 years near Washington, D. C. There are many buildings of this type in England, where the climate is relatively damp.

Every builder planning to use adobe should check the Federal Housing Authority requirements for his State.

KINDS OF SOIL

The word "adobe" is used to designate a particular kind of soil, and there prevails a general impression that this material is essential for the making of sun-dried brick. Most clayey loams, except those with a high clay content, are suitable, but it is not practicable to

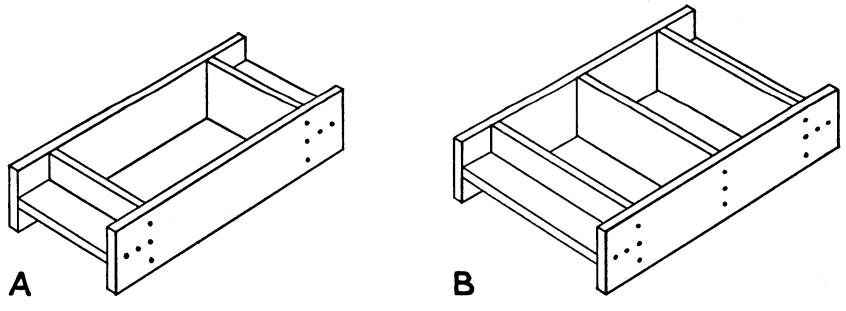

Figure 4.—Forms used for molding adobe brick: *A*, Single form; *B*, double form.

make a selection on the basis of soil analyses. Soils having a high clay content shrink or crack badly when drying, and sandy soils do not have sufficient bonding material to prevent crumbling. Neither of these soils should be used alone for brick, but a very good building material can be obtained by mixing them in proportions that will overcome the undesirable qualities of each. The best way to determine the fitness of a soil is to make a sample brick and allow it to cure in the open, protected from moisture. It should dry without serious warping or cracking. Frequently a suitable earth can be had from excavations for cellars.

MAKING THE BRICK

FORMS

The forms commonly used for molding the brick are shown in figure 4. These are made of lightweight surfaced lumber. Sometimes the inside surfaces are lined with metal to insure brick of true clean-cut shape by preventing adherence of the mud to the sides of the form. Unlined forms are more difficult to clean, since the mud has a tendency to stick to wood. The inside dimensions of the forms should be those of the desired brick.

SIZE OF BRICK

The sizes of brick commonly made and their approximate weights are as follows:

4 by 8 by 16 inches, 28 pounds
4 by 10 by 16 inches, 35 pounds
4 by 9 by 18 inches, 36 pounds
4 by 12 by 18 inches, 48 pounds
5 by 12 by 16 inches, 53 pounds
5 by 10 by 20 inches, 55 pounds
5 by 12 by 18 inches, 59 pounds
6 by 12 by 24 inches, 100 pounds

Small bricks are suitable for building poultry houses and other small structures (fig. 5). The 5- by 10- by 20-inch brick is used for

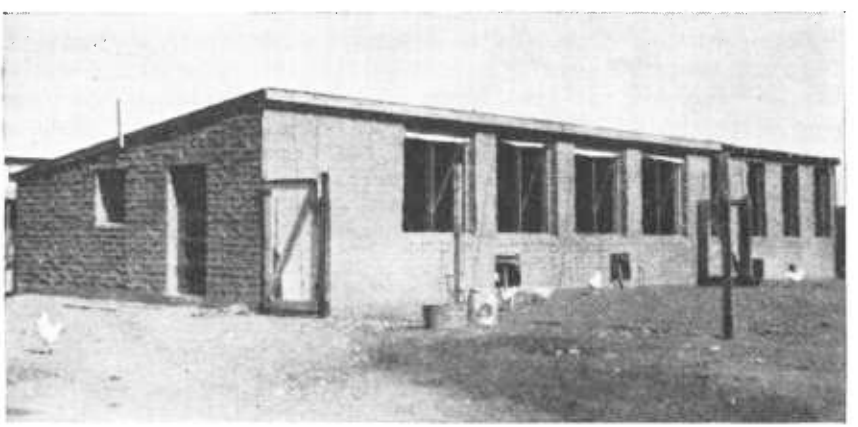

Figure 5.—Poultry houses of adobe are in common use in the Southwest. Lime-mortar joints offer resistance to erosion by wind-driven sand.

10-inch walls and the 4- by 12- by 18-inch brick for walls from 12 to 30 inches thick. The 6- by 12- by 24-inch brick is too heavy for convenient handling.

PREPARING THE SOIL

Only a sufficient quantity of soil for a day's work should be prepared at one time. Cloddy soil should be wetted to soften lumps a day before bricks are to be made. The proper quantity of soil is piled in a 3- or 4-inch layer, wet thoroughly, and puddled into a mucky mud, generally by men tramping barefooted through the mass or by mixing with a mortar hoe (fig. 6, *A*). When the earth is uniformly wet, straw

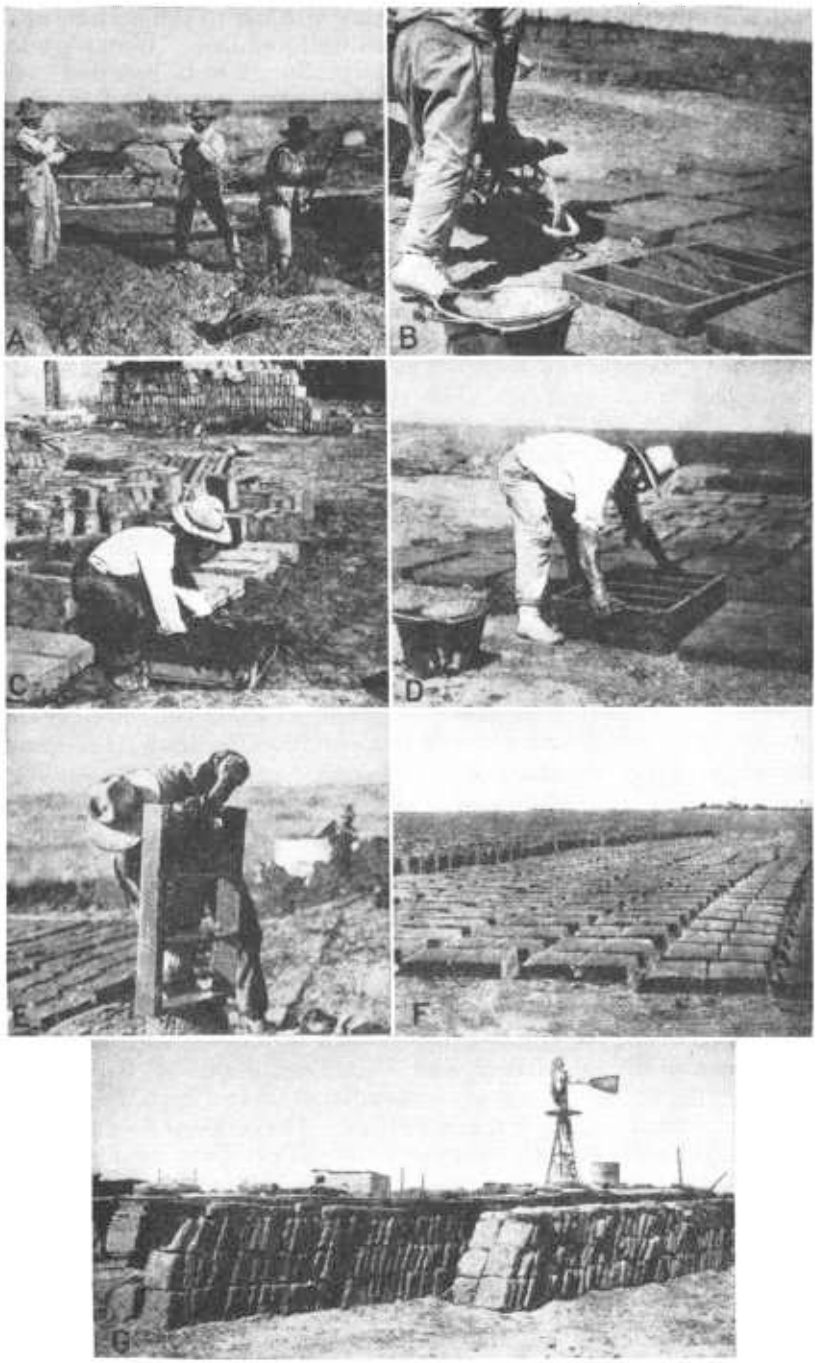

Figure 6.—Making adobe brick: *A*, Mixing the soil; *B*, filling forms; *C*, smoothing the top; *D*, removing form; *E*, washing form; *F*, drying the brick; *G*, bricks stacked.

is thrown on top of a layer ¾ to 1 inch thick and tramped into the mud. To prevent the straw from being worked to the bottom of the pile do not add it until the soil has been well puddled. Water is added as necessary to produce a mixture plastic enough to be handled with a six-tined fork yet stiff enough to stand up upon removal of the form. Since the quality of the brick is improved by thorough puddling, a hoe should be used in the process.

Machine mixing is speedier and much more satisfactory than hand mixing and should be used where power and equipment are available. The soil, sand (if needed), water, and straw may be mixed together. Additional water may be added if the mix is too stiff, but just enough water should be used to make the mud workable. A hoe-type plaster mixer, a pugmill, or even an old dough mixer will break up and mix soils better than a concrete mixer.

The quantity of straw required varies with different soils and is best determined by experiment. The sole purpose in adding straw is to allow the bricks to "breathe" while curing; this promotes uniform drying through the mass and minimizes shrinkage cracks. Too much straw or straw mixed with manure impairs the strength of bricks. Usually not more than 1 part by volume of loose, clean straw is used to 5 parts of mud, and occasionally bricks are made without straw. Long straw is difficult to distribute uniformly. The straw should preferably be cut in lengths of 2 to 6 inches.

In areas less arid than the Southwest and where buildings may be exposed to floodwaters, it is recommended that stabilizing admixtures be added to the mud. Portland cement or emulsified asphalt are the admixtures most commonly used. The National Bureau of Standards report BMS–78, on tests of five earth walls, shows the benefit derived from such admixtures.

MOLDING THE BRICK

A fairly smooth area of ground should be selected for the molding site. If ground having a good native sod is not available, level off a suitable site and scatter straw over the part to be used for the molding floor to prevent the brick from sticking to the ground.

The prepared mud is generally carried to the molding site in wheelbarrows and forked or shoveled into the forms (fig. 6, *B*). The molder presses it into the form with a tamper or with his hands, taking care to fill all corners, and smoothes the top off with a stick or trowel (fig. 6, *C*). The form is then lifted away (fig. 6, *D*), cleaned of adhering mud (fig. 6, *E*), and refilled. If the form does not come off easily, the sides may be loosened from the bricks by tapping.

CURING

In a few days, depending upon the weather, the bricks are stood on edge in such manner as to insure fairly equal exposure of the two sides to the sun and wind and allowed to dry for a week (fig. 6, *F*). When dry enough to handle, the loose dirt and straw are scraped from the bottom of the bricks, which are then piled, protected from rain, and left to cure. Two or three weeks is generally required for the brick to dry sufficiently for use (fig. 6, *G*).

Brick should not be made in freezing weather or when the season is unsuitable for drying. Care must be taken to protect uncured brick from frost as they will disintegrate if frozen before being thoroughly cured.

RATE OF WORK

Usually two to four men work together and mix and mold eight to ten 4- by 12- by 18-inch bricks per man-hour of hand labor. The number produced will, of course, vary with the skill of the crew and the convenience of arrangements for handling.

METHOD OF LAYING BRICK

Adobe brick are laid in the wall in much the same manner as are ordinary burnt brick (fig. 7), care being taken to break joints and to build up strong, well-bonded corners. Generally mud without straw is used for mortar, and the bricks are laid with ½- to 1-inch joints.

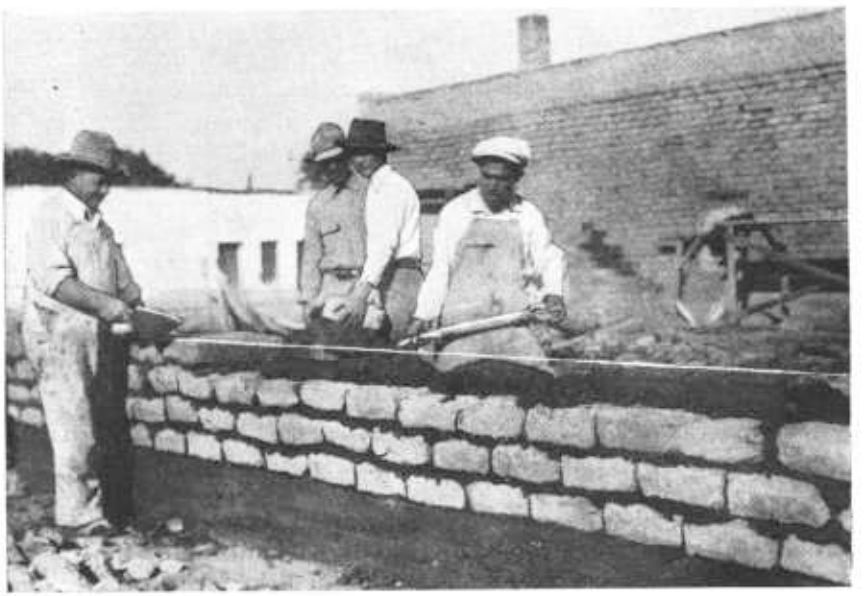

Figure 7.—Laying adobe brick in mud mortar.

Lime mortar, made by mixing 1 part lime and 3 parts sand, or cement mortar is frequently used in high-grade structures. Although higher in cost than mud, it sets faster and adds to the wall strength. When the brick are made of stabilized earth, the same material is often used for mortar.

About 1 cubic foot of mortar or mud is required to lay 25 to 30 bricks 4 by 10 by 16 inches in size, with ½-inch joints. A crew of 3 men should place between 300 and 350 bricks in the wall in 8 hours.

The number of bricks required to build 100 square feet of wall depends upon the size of the bricks and whether the end or side is

exposed: thus, when 4- by 10- by 16-inch bricks are laid with ½-inch joints, 305 are needed for 100 square feet of wall 16 inches thick, and 190 for the same area 10 inches thick.

Nailing blocks and anchor bolts for securing frames, trim, sills, and plates are required as in other types of masonry and are built in as the wall is raised. Sometimes bolt holes are bored with an anger and the bolt bedded in the hole with cement mortar.

The height to which a wall may be carried depends upon its thickness and whether or not buttresses are used at frequent intervals to serve as braces. Bearing walls in one-story and in the upper wall of two-story buildings should not be less than 12 inches thick and the story height limited to 10 times the wall thickness. The lower wall in a two-story building should not be less than 18 inches thick. Adobe structures should in general not be more than two stories high (fig. 8).

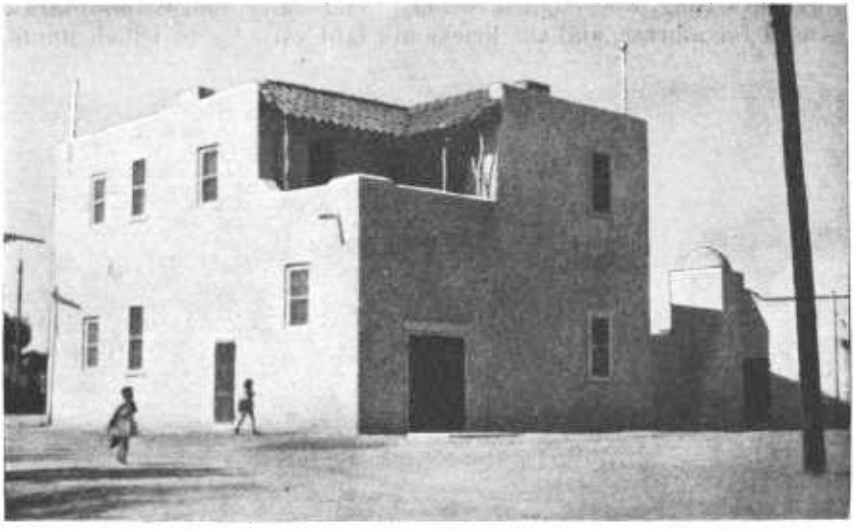

Figure 8.—Two-story apartment house of stuccoed adobe.

To avoid possible damage by wind during construction, it is advisable to brace high, long walls temporarily until they have been permanently secured by plates and ceiling or floor joists. In regions subject to earthquake, special bracing and anchorage should be provided and local building authorities consulted.

FOUNDATIONS

A good watertight foundation is essential for all permanent buildings and especially for those made of adobe, which deteriorate rapidly when subjected to continued moisture or the occasional erosive action of water (fig. 9). In general, foundations similar to those used for masonry walls are suitable.[2] Inexpensive foundations are shown in figure 10.

[2] See U. S. Dept. Agr. Farmers' Bul. 1869, Foundations for Farm Buildings.

Figure 9.—Better type of house built by Mexicans. Lack of masonry foundation and protection at the ground caused the lime stucco to fail. This defect should be remedied as suggested in figure 10. The decorative coping of burnt brick, the short chimney carried by the wall, and the roof outlets are features of interest. This house is more than 50 years old.

The following recommendations should be followed in order to obtain stability and protection of the earth walls:

All footings should be carried below the frost line and to solid ground.

Footings should be wide enough to distribute the wall loads uniformly to the soil upon which they rest and within the limit of the bearing power of the soil.

Foundations should be of watertight concrete or of stone or brick laid in cement mortar, and of a proper size to bear the imposed weight. In arid localities waterproofed adobe foundations may be used for minor structures.

The tops of foundations should be at least 12 inches above the outside grade, and 6 to 8 inches (fig. 10, *A*) above concrete floors, to protect the earth walls from the splash of rain and of water used in cleaning the floors.

A dampproof course [3] should be provided on top of the foundation to prevent moisture rising by capillarity from the ground into the adobe.

Screened openings (fig. 10, *B*) should be provided in the foundations for ventilation of the space under wood floors. They should be placed about 10 feet apart.

The tops of foundation walls should provide bearing for the first-floor joists and full bearing for the adobe brick of the wall above (fig. 10). A continuous bearing plate should be provided for the floor joists where the foundation wall is built of adobe (fig. 10, *C* and *D*).

[3] Described in U. S. Dept. Agr. Farmers' Bul. 1572, Making Cellars Dry.

Although adobe is frequently used in dry climates as a foundation material for small dwellings and minor utility buildings, this is not recommended as a general practice because the splash from rain and roof drainage and erosion by wind may seriously damage the earth

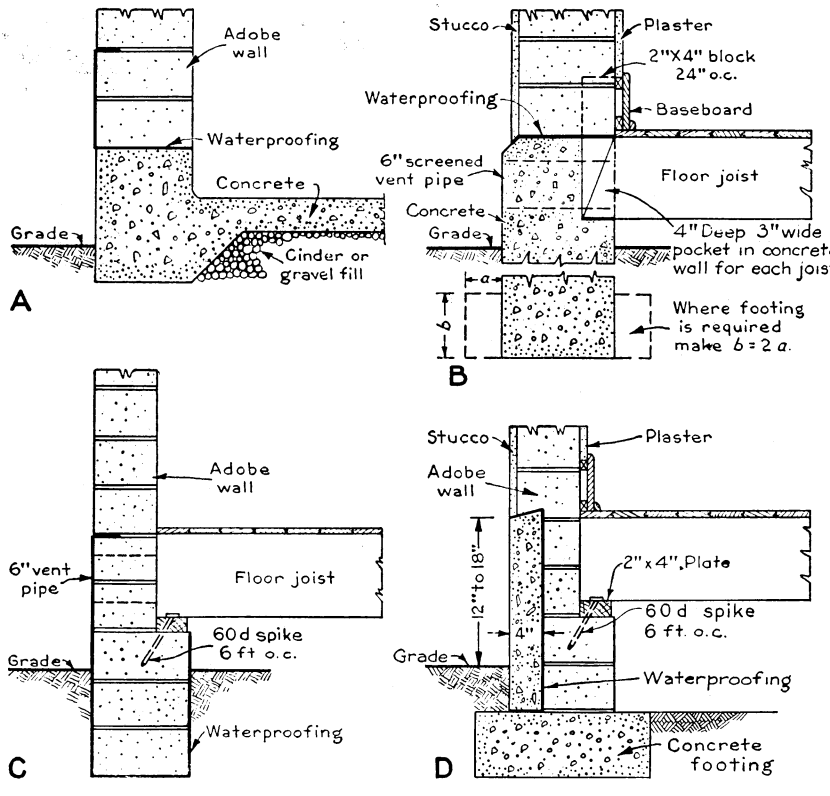

Figure 10.—A, Shallow footing suitable for dry climates, where it will not be subject to undermining by surface drainage. Outside waterproof protection is provided for walls that are not stuccoed, and an inside curb to keep the earth dry when the floor is cleaned with water. *B*, Suggested footing for thick walls. It provides full bearing for the adobe wall and protects the outer part from erosion. *C*, Adobe foundations for minor structures are afforded a fair measure of protection from ground moisture in dry climates by heavily coating the bottom of the trench and both sides of the bricks with tar. The excavation must be made wide enough to permit application of the tar to the wall surfaces. The walls and trench bottoms could be plastered to advantage with 1 inch of 1:2½ cement mortar. *D*, Method of repairing walls eroded near the grade line. The adobe bricks are cut back 4 inches and replaced with a concrete base extending below, and at least 12 inches above, the grade.

walls. Where expediency warrants this type of foundation, a well-drained site should be chosen, the lower part of the wall should be protected by cement stucco or by some other method of waterproofing (fig. 10, *C*), and special provision should be made to carry roof drainage away from the walls and footings.

WINDOWS AND DOORS

Door and window frames usually are set in place and the walls built against them, but it is rather difficult to fasten the frames securely so as to prevent their working loose as the walls dry and settle. Blocks consisting of 2- by 4-inch creosoted lumber, 12 inches or more in length, built into the earth walls and to which the frames are nailed (fig. 11), are fairly satisfactory; there should be three blocks on each side of the opening. Sometimes a rough frame is bolted to the wall, the finished frame being nailed to it. When the wall is to be plastered or stuccoed, provision should be made to extend the stucco under the trim in order to obtain weathertight joints (fig. 12).

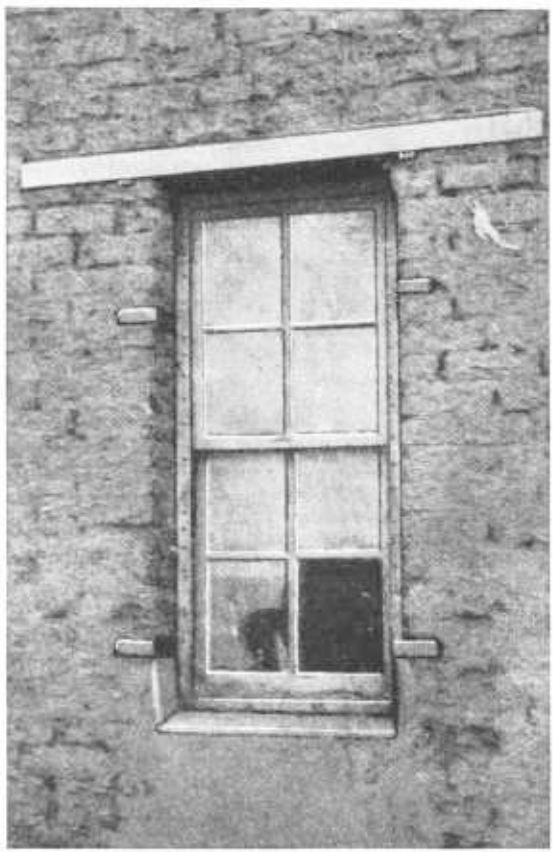

Figure 11.—Blocks at the sides of openings to which window and door frames are secured. These should be hidden by the brick unless outside trim is to be applied.

Lintels are required over openings to carry the wall above, the roof rafters, and the second-floor joists. They may be of the same materials and dimensions as would be used under like conditions in masonry walls. They should extend 9 to 12 inches beyond the jambs to afford proper bearing on the adobe (fig. 11). Lintels should be set ½ to 1 inch higher than the window or door frame to allow for settlement in the wall.

Arches can be built of adobe brick cut to the required shape or formed in special molds (fig. 13).

A very good practice in adobe construction is to provide a continuous concrete beam 4 to 6 inches thick and as wide as the wall, under floor and roof plates (fig. 14). Such beams if reinforced with two ⅜-inch steel bars on each side will not only distribute the floor and roof loads uniformly on the wall but also stiffen the whole building and tie it together. Wood should not be used for this purpose.

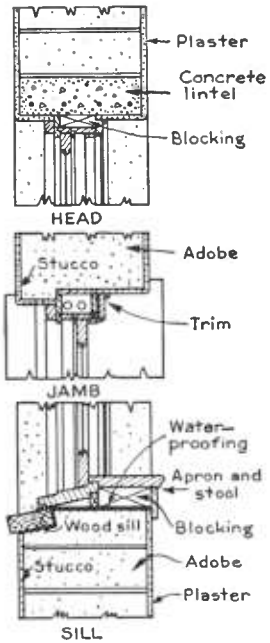

Figure 12.—Detail of window. A stone or concrete sill, although higher in cost, would be more satisfactory than a wooden one.

OUTSIDE AND INSIDE WALL COATINGS

OUTSIDE TREATMENTS

Uncoated adobe walls will last from 25 to 40 years in arid climates if the top and base are protected from moisture. An outside coating, however, increases the durability and improves the appearance of the structure, and is essential in humid localities.

No covering for walls of clayey soils has been developed as yet that has the four desired qualities of good appearance, watertightness, durability, and cheapness. Bituminous coatings are very satisfactory in many respects but on account of their dark color are not acceptable as finish. Hot tar, cold-pitch asphalt, and Cunningham coal-tar paint are coatings of this type.

Cunningham coal-tar paint is a mixture of 1 part portland cement, 1 part kerosene, and 4 parts coal tar by volume. The cement and kerosene are mixed first and then stirred into the tar. The paint is applied with a brush or swab. The tar should be the liquid procured from local gas works or from naval supply stores, known as water-gas tar. It is not the pitch ordinarily used that requires heating or thinning with a solvent. The consistency can be modified by reducing the quantity of cement or by increasing the quantity of kerosene. An excess of cement produces a thick paste that has value in stopping holes not filled by paint of normal consistency. It is better to use the paint immediately after mixing, although it can be held for a

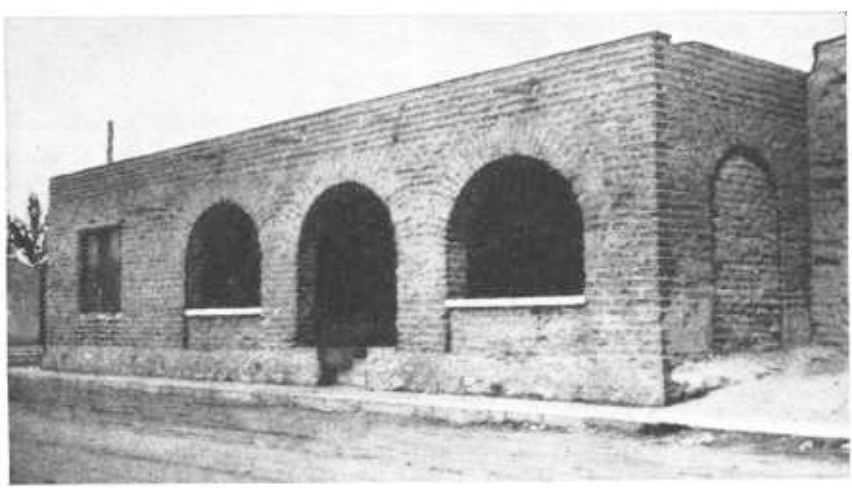

Figure 13.—Adobe brick arches, laid in lime mortar, with a span of 6 feet between 12- by 24-inch columns.

considerable time if kept in closed receptacles so that the kerosene will not evaporate.

Before any coatings are applied the walls should be primed with a coat of thin water-gas tar. The final durability and appearance will be improved by an application of aluminum paint over the whole surface or as a trim. Ordinary paints cannot be used successfully over tar or asphalt.

Whitewashes [4] are cheap, easily applied, and decorative when fresh. They are not very durable or waterproof, but are frequently used for low-cost structures.

If the walls are to be painted, care should be taken in making and laying the brick to provide a smooth wall surface, as it is difficult to paint over rough adobe brickwork. Linseed-oil-lead paint is probably the most durable and satisfactory of all paints when used on stabilized adobe, but is rather expensive. The surface should first be sized or primed with linseed oil or a thin coat of glue sizing made of 1 pound of cheap glue to 1 gallon of hot water. The first coat of paint should be thinned slightly, but the second coat may be applied as it comes from the can.

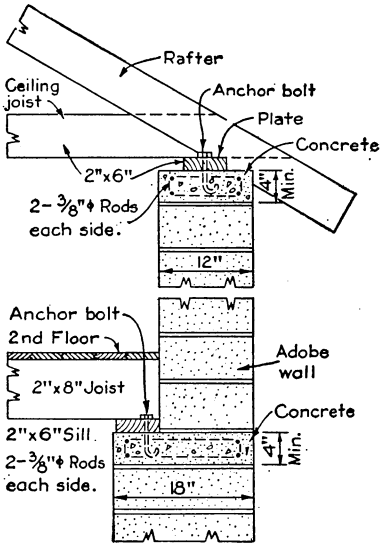

Figure 14.—Cross section of wall showing concrete tie beams with 3/8-inch reinforcing bars. The lower wall in a two-story building should not be less than 18 inches thick.

Frequently in low-cost buildings the walls are plastered with stiff mud mortar. It should be applied in two coats and be made permanent by painting. A sandy surface shrinks less and holds paint better. Two parts of sand should therefore be added to each part of mud. This mixture will adhere to earth walls better than lime mortar and, when dry, forms a good base for paint or whitewash, especially if waterproofed.

Stuccoes and inside plasters should not be applied for at least 2 months after a wall is built, to allow for settling and shrinkage. Unless the wall is very smooth and free of irregularities, the stucco should be put on in two coats or layers, and three coats are recommended for first-class work. All undercoats should be heavily scored (fig. 15) to provide bond for succeeding coats.

A bond or key should be provided to increase the adherence both of outside stucco and of inside plaster to earth walls. As stated previously, the protruding joints of lime mortar have considerable value in this respect. Figure 16 illustrates a method of using nails as a bond for stucco or plaster. Another method is to nail the scratch coat to the wall with tenpenny or twelvepenny nails spaced about 12

[4] U. S. Dept. Agr. Farmers' Bulletin 1452, Painting on the Farm, and Farmers' Bulletin 1500, Rammed Earth Walls for Buildings, contain formulas for whitewash and other coatings.

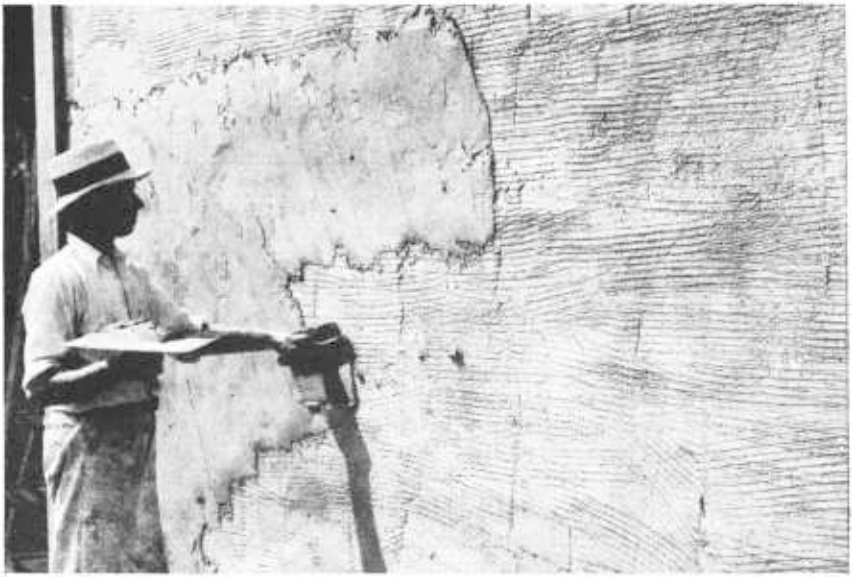

Figure 15.—The undercoats of both stucco and plaster should be scored or scratched to form a bond for succeeding coats.

inches at random—not on a straight line. The nailing should be done within 15 minutes of applying the mortar and the nailheads driven flush or within one-eighth inch of the mortar surface. For first-class work, metal lath should be used as a base for stucco.

The stucco scratch coat is sometimes thrown on the wall with a broom or a brush made of reeds (fig. 17) instead of being applied by a trowel. It is difficult, however, to obtain uniform thickness by this method.

Stucco made by mixing 1 part lime putty and 3 parts sand, by volume, is fairly durable and adheres to earth walls better than does portland-cement stucco. When properly applied, lime stucco has greater resistance to water than is commonly supposed, but, being softer than cement stucco, it is not so durable when subjected to erosion by wind-borne material or to continued moisture.

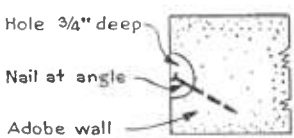

Figure 16.—Holes about three-fourths of an inch deep in each block are made by striking the adobe with a sharp tool. Eightpenny or tenpenny nails are driven in, at an angle to prevent their pulling out, so that the heads are flush with the wall and out of the way of the trowel when the plaster is applied.

Portland-cement stucco made by mixing 1 part portland cement and 3 to 4 parts sand, by volume, is used to resist water and mechanical wear but is applied preferably over metal lath to minimize the tendency to crack. It can be handled to better advantage if, for each bag of cement, 10 pounds of hydrated lime (or the equivalent in lime paste) is put in the mortar.

Ten pounds of hydrated lime is equivalent to about one-fourth cubic foot; 1 cubic foot of the paste requires 44 pounds of hydrated lime or 27 pounds of quicklime. Hydrated-lime paste should stand for at least 24 hours to insure complete slaking. Quicklime should be slaked

Figure 17.—Mortar applied with a broom. Undercoats, when applied by this method, form a good bond for the troweled finish.

at least a week before it is used, the longer the interval the better. Hydrated lime, in powder form, is nearly two and one half times as bulky as portland cement, weighing 40 pounds per cubic foot as compared with 94 pounds for cement.

To produce good stucco, care must be taken to prevent too rapid drying. Wetting the walls prior to stuccoing or plastering and covering the finished surface with wet bags or spraying it with water for several days will reduce the tendency to crack.

The texture or finish of stucco depends upon the manner of working the final coat. Directions for applying and finishing cement and lime stucco may be found in trade publications.[5]

INSIDE TREATMENTS

The inside wall surfaces of smaller farm buildings frequently are not plastered. A plaster consisting of 2 parts sand and 1 part clayey loam may be applied to obtain a smooth surface. This mud plaster is fairly durable if kept dry. Sometimes a skim coat of lime or cement mortar is applied over the mud base to improve appearance and wearing quality. A cheap, durable, and decorative finish may be obtained by covering the mud plaster with paint, calcimine, or paper.

Lime mortar or commercial plasters, applied over metal lath, should be used on the interior walls of residences.

Because animals have the habit of licking earth walls and rubbing against them, the corners of buildings should be protected by corner boards and the doorjambs by casings. The use of portland-cement mortar for laying the bricks at corners within reach of animals might

[5] Portland Cement Association, Chicago, Ill., and National Lime Association, Washington, D. C.

discourage the habit and prevent damage. Interior surfaces within reach of animals tied or penned, as in a stall, should be protected by a well-sanded tar coating or by cement plaster.

ROOFS

All kinds of roofing are used on adobe buildings. The chief considerations are low cost, watertightness, and protection of the earth walls. Sloping roofs with wide eaves afford the greatest protection from damage by rains. Only such roofs, securely anchored to the walls (fig. 18), should be employed in humid localities.

Unless the roof is well insulated,[6] much of the insulating value of the earth walls is nullified. Metal roofing alone provides no insulation and in cold climates will sweat when used on animal shelters or on heated storages where moisture is present. Water formed by condensation will drip, causing annoyance and, in time, serious damage.

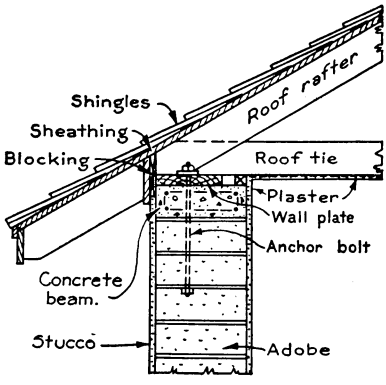

Figure 18.—Anchoring roof to wall.

Flat roofs with parapets are very popular in arid regions because earth can be placed upon the roof covering as insulation against the hot sun. In humid localities, where earth cannot be used as an insulator, the roof should have a slight pitch to shed rain water and should be insulated with one of the commercial materials manufactured for this purpose. Explicit directions for use of the materials can be had from the manufacturers of the various products.

Metal can be used to cover flat decks, but the seams must be made watertight with solder and the surface must be kept well painted.[7] Good built-up roofing is very satisfactory on flat roofs and is commonly used. This consists of 4 or 5 layers of waterproof felt laid alternately with hot tar or asphalt coatings, the top being covered with gravel, slag, or, in dry climates, earth.

Although good-quality built-up roofing is more expensive than the coverings widely employed in the so-called adobe region of the Southwest, it compares favorably with metal and other long-life coverings and may be used on flat-roofed houses of the better class. Great care must be exercised to provide tight flashings around parapets and chimneys and ample drainage outlets. Outlet troughs 3 feet long, shown in several of the illustrations, are commonly used on small buildings to throw the roof drainage away from the base of the wall.

Two roofs that have given good service in New Mexico are illustrated in figure 19. Very cheap roofs, suitable only for regions having little or no rainfall, consist of metal sheets laid over the rafters, with or

[6] See U. S. Dept. Agr. Misc. Pub. 633, Your Farmhouse—Insulation and Weatherproofing.

[7] See U. S. Dept. Agr. Farmers' Bul. 1751, Roof Coverings for Farm Buildings and Their Repair.

without sheathing, and covered with sod or earth. The life of the metal can be extended by painting both sides with Cunningham coal-tar paint (p. 12). The tops of parapets should be waterproofed and protected against erosion by a masonry cap. In arid regions adobe bricks are used for this purpose on low-cost houses, but this necessitates keeping a supply of brick on hand for repairs.

An interesting type of roof used on pioneer buildings is illustrated in figure 20. Although such roof can be made tighter than might be expected, it is suited only to secondary sheds, porches, and temporary buildings, unless sheathing is used over the 1-inch branches instead of cane or straw and a durable covering over the sheathing.

CHIMNEYS

Chimneys for better class buildings should be constructed in accordance with generally accepted good practice.[8] They should rest on firm foundations extending below the action of frost.

Adobe is frequently used for chimneys and fireplaces, but when it is so employed the inside of the fireplace should be lined with fire-clay brick and the flues with flue lining. Chimneys with 4-inch walls of burnt brick, lined with terra cotta, are frequently to be found in adobe houses. Where walls are thick and only a short chimney is required, it can be safely built as shown in figure 21. The tops of chimneys should be capped with masonry.

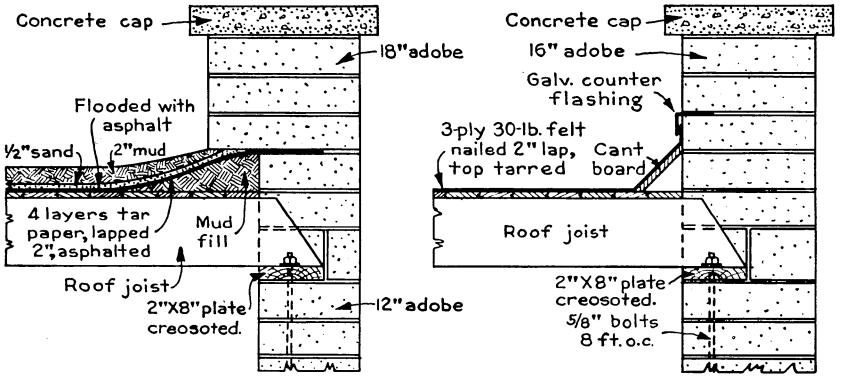

Figure 19.—Two methods of building flat roofs.

BOUNDARY WALLS

Adobe can be used economically for fences and boundary walls and, in arid sections, will last longer than the average fence even when foundations and stucco are omitted. If stuccoed and provided with a good foundation and cap, they are ornamental and durable.

[8] See U. S. Dept. Agr. Farmers' Bul. 1889, Fireplaces and Chimneys.

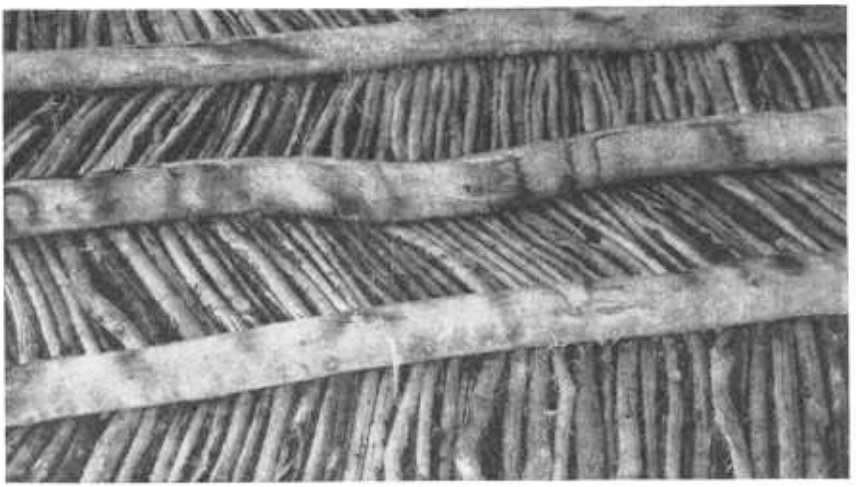

Figure 20.—Under side of a roof consisting of cottonwood logs 4 to 8 inches in diameter spaced 24 to 30 inches on centers. The logs are covered with 1-inch willow twigs laid diagonally as support for a layer of dry rushes or straw held in place with 2 to 4 inches of adobe mud or sod.

ADDITIONAL INFORMATION

A list of sources of additional information on adobe construction has been prepared by the Department of Agriculture. This list, Sources of Information on Earth Construction, may be procured from the Division of Farm Buildings and Rural Housing, Bureau of Plant Industry, Soils, and Agricultural Engineering, Beltsville, Md.

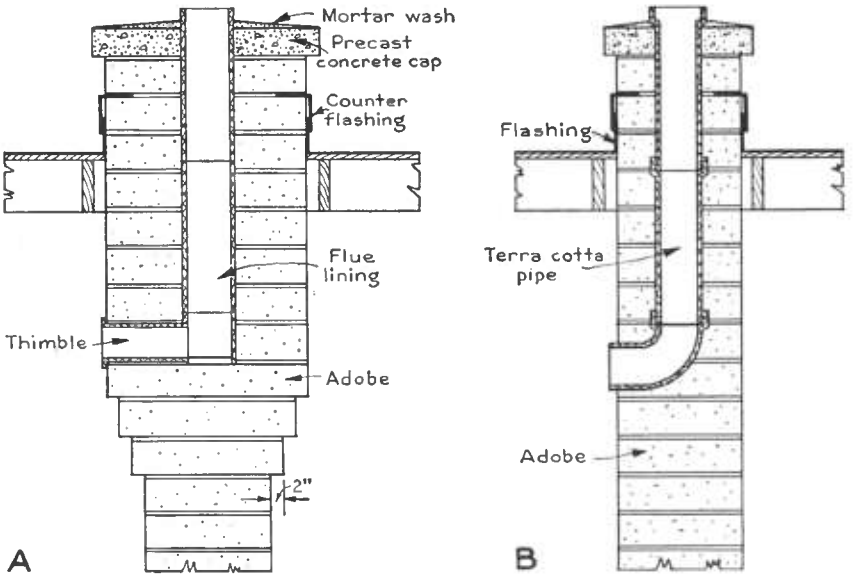

Figure 21.—Chimneys built of adobe bricks: *A*, Corbeling to obtain thick walls that lessen the fire hazard due to erosion of mortar in the joints; *B*, in very cheap houses and shelters a 6-inch glazed tile is often built into the adobe wall as shown.